

Earth's Atmosphere and Weather


6-4 The student will demonstrate an understanding of the relationship between Earth's atmospheric properties and processes and its weather and climate. (Earth Science)

6-4.1 Compare the composition and structure of Earth's atmospheric layers (including the gases and differences in temperature and pressure within the layers).

Taxonomy level: 2.6-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have not been introduced to the concepts of Earth's atmosphere and its layers in previous grades. Air pressure is also a new concept. In 2nd grade (2-3.1), students explained the effects of moving air as it interacts with objects. In 3rd grade (3-4.1), students classified different forms of matter (including gases). In 4th grade (4-4.3), students compared daily and seasonal changes (including wind speed). These previous experiences can aide the study of the atmosphere here.

It is essential for students to know that Earth's *atmosphere* is the layer of gases that surrounds the planet and makes conditions on Earth suitable for living things.

<i>Atmospheric Layers</i>	Earth's atmosphere is divided into several different <i>atmospheric layers</i> extending from Earth's surface outward	<ul style="list-style-type: none"> the <i>troposphere</i>, where all weather occurs the <i>stratosphere</i>, where the ozone layer is contained the <i>mesosphere</i> the <i>thermosphere</i> the <i>exosphere</i> 	Earth's Surface  Space
<i>Atmospheric Gases</i>	Nitrogen and Oxygen Ozone Water vapor and Carbon dioxide Trace gases, for example argon	<ul style="list-style-type: none"> the two most common gases; found throughout all the layers a form of oxygen found in the stratosphere important gases for weather conditions; found in the troposphere play an insignificant role 	
<i>Atmospheric Temperatures</i>	Differences in temperature separate the layers	<ul style="list-style-type: none"> As altitude increases, temperature decreases in the <i>troposphere</i> The <i>stratosphere</i> is cold except in its upper region where ozone is located The <i>mesosphere</i> is the coldest layer Even though the air is thin in the <i>thermo- sphere</i>, it is very hot The cold regions of outer space 	

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		extend from the <i>exosphere</i>	
<i>Atmospheric Pressure</i>	The <i>air pressure</i> , the force exerted by the gases pushing on an object, is greatest near the surface of Earth, in the <i>troposphere</i> .	<ul style="list-style-type: none"> Air pressure decreases through the layers farther out from the surface as Earth's pull of gravity decreases. 	Troposphere pressure decreases ↓ Exosphere

It is not essential for students to know the exact distance between each layer or the temperatures of the layers. The chemistry of the different gas particles (such as H₂ is an element, and CO₂ is a compound) is not expected at this grade level. They do not need to compare the properties of pure air with air containing particulate matter and unnatural gases, polluted air.

Assessment Guidelines:

The objective of this indicator is to *compare* the composition and structure of Earth's atmospheric layers; therefore, the primary focus of assessment should be to detect similarities and differences between the layers (including the gases and differences in temperatures and pressure within the layers). However, appropriate assessments should also require students to *identify* common gases or the layer where weather occurs; *recall* where the ozone layer is located; or *classify* by sequencing the layers.

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6.4.2 Summarize the interrelationships among the dynamic processes of the water cycle (including precipitation, evaporation, transpiration, condensation, surface-water flow, and groundwater flow).

Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: In 4th grade, students summarized the processes of the water cycle (including evaporation, condensation, precipitation, and runoff) (4-4.1) and classified clouds according to their three basic types (4-4.2). In 5th grade (5-4.2), students compared the physical properties of the states of matter. The addition of transpiration and the two areas of run-off are new information. In 7th grade (7-4.5), students will study groundwater zones and surface water drainage basins.

It is essential for students to know that water is always moving between the atmosphere (troposphere) and surface of Earth. Each components of the *water cycle* process has certain conditions under which each form of precipitation develops:

Precipitation

- After condensation occurs (forming clouds), water droplets fall in various forms of *precipitation* – rain, snow, freezing rain, sleet, or hail, depending upon weather conditions.
- Temperature variations within clouds and/or within the region between the cloud and Earth allows for the various forms of precipitation.

Evaporation/Transpiration

- Water enters the atmosphere as water vapor through evaporation and transpiration, plants releasing water vapor.

Condensation

- *Condensation* happens in the atmosphere as water vapor changes to water droplets.
- Clouds form as a result of condensation.
- *Dew* forms when water vapor condenses directly onto a surface;
- *Frost* forms when water vapor changes from gas directly to ice crystals on a surface when the temperature at which condensing would take place is at the freezing point or below.

Run-off

- If precipitation falls on land surfaces, it always attempts to move back toward sea level as *surface-water flow* or *groundwater flow*.
- The surface that receives the precipitation determines its flow back towards sea level. Examples are:
 - Water will remain on the surface when the surface is not porous or the precipitation is falling too fast for the water to sink into the ground.
 - Water will sink into the ground when the surface is porous and there is lots of space in the soil to hold the water.

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It is not essential for students to know what happens to the individual water particles as they change from one state of matter to another.

Assessment Guidelines:

The objective of this indicator is to *summarize* the interrelationships among the processes of the water cycle; therefore, the primary focus of assessment should be to generalize major points about the parts of the water cycle (including precipitation, evaporation, transpiration, condensation, surface-water flow, and groundwater flow). However, appropriate assessments should also require students to *identify* parts of the water cycle; *compare* one part of the water cycle with another; or *illustrate* parts of the water cycle using words, drawings, diagrams, or symbols.

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6.4.3 Classify shapes and types of clouds according to elevation and their associated weather conditions and patterns.

Taxonomy level: 2.3-A, B Understand Conceptual Knowledge

Previous/Future knowledge: In 4th grade (4-4.2), students classified clouds according to their three basic types (cumulus, cirrus, and stratus) and summarized how clouds form.

It is essential for students to know that clouds that form from the condensation of water vapor are classified by a basic shape and associated weather conditions and patterns. Clouds can be classified in three major groups:

Cumulus

- Clouds formed at medium or low elevation.
- Cumulus clouds are puffy with flat bottoms.
- When cumulus clouds are white they often signal fair weather, but when they are darker, they may signal rain or thunderstorms.

Cirrus

- Clouds formed at high elevations; wispy clouds usually consisting of ice crystals that signal fair weather or may also signal an approaching warm front.

Stratus

- Clouds formed at medium or low elevation; spread out layer upon layer covering a large area
- As stratus clouds thicken, precipitation usually occurs over that area.

It is essential for students to know the names of many clouds are a combination of one of the three basic shapes and a prefix or suffix. The basic shape name can be combined with the appropriate prefix or suffix listed below as clues to the weather conditions that may result.

- Combinations of those shapes can be used with *nimbus*, which means “rain”, for example, cumulonimbus or nimbostratus.
- A *cumulonimbus* cloud, also called a thunderhead, is often part of thunderstorm conditions that may accompany a cold front.
- The prefix *alto-* may also be used to indicate medium-level clouds formed at about 2-6 kilometers up into the atmosphere, for example, altocumulus or altostratus.

Clouds that form when condensation occurs at or near the ground are called *fog*.

It is not essential for students to know the details of cloud formation, condensation nuclei and dew point. Knowing the numerous combinations of cloud names is also not essential.

Assessment Guidelines:

The objective of this indicator is to *classify* shapes and types of clouds according to elevation and their associated weather conditions and patterns; therefore, the primary focus of assessment should be to determine the cloud category based on the description. However, appropriate assessments should also require students to *recognize* a cloud type based on a description;

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illustrate cloud shapes or types through pictures or words; or *compare* weather conditions associated with cloud types.

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6.4.4 Summarize the relationship of the movement of air masses, high and low pressure systems, and frontal boundaries to storms (including thunderstorms, hurricanes, and tornadoes) and other weather conditions.

Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have been introduced to the conditions, effects, and safety issues of severe storms in 4th grade (4-4.4) but not to their relationships with fronts and low-pressure systems. Using these concepts to make predictions is a future application at the high school level.

It is essential for students to know that the interactions between *air masses*, *fronts*, and *pressure systems* result in various weather conditions.

Air masses

- Huge bodies of air that form over water or land in tropical or polar regions.
- Temperature and humidity conditions (for example, warm or cold air, humid or dry air) within the air masses as they form are important to the resulting weather conditions when air masses move.

Fronts

- As these air masses move and collide with each other, *fronts* form at the boundaries between the air masses.
- Depending upon the air masses involved, a *warm front*, *cold front*, *stationary front*, or *occluded front* can develop.
 - When a warm air mass collides and rides over a cold air mass, the resulting *warm front* may produce long periods of precipitation and warmer temperatures.
 - When a cold air mass collides and slides under a warm air mass, the resulting *cold front* may produce thunderstorms and sometimes tornadoes and cooler temperatures.
 - When neither a cold air mass nor a warm air mass moves at a frontal boundary, the resulting *stationary front* may produce long period of precipitation.
 - When a cold air mass pushes into a warm air mass that is behind a cool air mass, the warm air mass is pushed up above the cooler air masses. The resulting *occluded front* may produce long periods of precipitation.

High/Low Pressure Systems

- Warm air rising or cold air sinking combined with the spinning of Earth causes the air to spin forming high and low pressure regions.
 - *High pressure systems* usually signal more fair weather with winds circulating around the system in a clockwise direction.
 - *Low pressure systems* with counterclockwise circulating winds often result in rainy and/or stormy weather conditions.

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Storms

- Severe weather conditions called *storms* occur when pressure differences cause rapid air movement.
- Conditions that bring one kind of storm can also cause other kinds of storms in the same area.
 - *Thunderstorm* is storm with thunder, lightning, heavy rains and strong winds; form within large cumulonimbus clouds; usually form along a cold front but can form within an air mass.
 - *Tornado* is a rapidly whirling, funnel-shaped cloud that extends down from a storm cloud; the very low pressure and strong winds can cause great damage to people and property; are likely to form within the frontal regions where strong thunderstorms are also present.
 - *Hurricane* is a low pressure tropical storm that forms over warm ocean water; winds form a spinning circular pattern around the center, or eye, of the storm; the lower the air pressure at the center, the faster the winds blow toward the center of the storm.

Other Weather Conditions

- Since weather is a condition of Earth's atmosphere at any time, weather conditions may include fair weather, showers or light rain, humid conditions, clear skies with cold conditions, days of clouds and precipitation, or others that do not necessarily involve storms.

It is not essential for students to know the specific names of all the air masses. The specifics of the formation of severe low-pressure storms, for example, tornadoes and hurricanes, are not necessary.

Assessment Guidelines:

The objective of this indicator is to *summarize* the relationships of the movement of air masses, high and low pressure systems, and frontal boundaries to storms and other weather conditions; therefore, the primary focus of assessment should be to generalize the major points about these factors in their relationship to storms (including thunderstorms, hurricanes, and tornadoes) weather conditions. However, appropriate assessments should also require students to *interpret* a diagram or description of a front; *compare* the weather conditions resulting high pressure and low pressure systems; or *predict* the weather condition(s) along fronts or within air masses.

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6.4.5 Use appropriate instruments and tools to collect weather data (including wind speed and direction, air temperature, humidity, and air pressure).

Taxonomy level: 3.2-C Apply Procedural Knowledge

Previous/Future knowledge: Only the barometer and sling psychrometer are new instruments to the study of weather. The others were introduced and used in 2nd and in 4th grade. (See 2-1.2, 2-3.4, 4-1.2, 4-4.5) This indicator also relates to a scientific inquiry indicator (6-1.1).

It is essential for students to know that in order to understand the conditions in weather systems and be able to make weather forecasts as precise as possible, weather data must be accurately collected.

NOTE TO TEACHER: Students must be able to use (not make) and accurately measure using the following instruments:

Anemometer

- A tool used to measure wind speed in miles per hour.

Wind vane

- A tool used to measure wind direction.
- Sometimes referred to as a wind-weather vane or a wind sock.
- Wind direction is described by the direction from which the wind is blowing.

Thermometer

- A tool used to measure air temperature in degrees Fahrenheit or Celsius.

Sling Psychrometer

- A two-thermometer instrument also referred to as a wet-dry bulb used to measure *relative humidity* (the amount of water vapor in the air).
- Temperatures readings are converted using a relative humidity table.

Barometer

- A tool used to measure air pressure in inches of mercury or millibars (mb).

Rain gauge

- A tool used for measuring the amount of precipitation in inches or centimeters.

It is not essential for students to make any of these instruments; they need to use them to collect weather data accurately. Students do not need to know how to use a hygrometer.

Assessment Guidelines:

The objective of this indicator is to *use* appropriate instruments and tools to collect weather data; therefore, the primary focus of assessment should be to apply a procedure to the tool that would be needed to measure wind speed, wind direction, air temperature, humidity, and air pressure. However, appropriate assessments should also require students to *identify* weather instruments

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that measure certain weather conditions; *interpret* the reading on the instrument for accurate data; or *interpret* the scale on weather instruments.

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6.4.6 Predict weather conditions and patterns based on weather data collected from direct observations and measurements, weather maps, satellites, and radar.

Taxonomy level: 2.5-B Understand Conceptual Knowledge

Previous/Future knowledge: Recording and predicting weather using weather maps, satellite images, and radar is new to this grade – some foundational concepts were given in 4th grade (4-4.6). Fourth grade did not use these tools to predict weather.

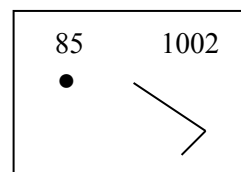
It is essential for students to know weather conditions and patterns can be predicted based on weather data collected from various sources.

Direct Observations and Measurements

- Basic weather conditions can be observed and/or measured (using the instruments listed in 6-2.5) or obtained from *meteorologists* at national weather data collection sites.
- In order to make weather predictions, the data should be collected on a regular basis over a period of time.
- This allows for the development of patterns in weather conditions from the analysis of the data.
- For example, a hurricane's path can be predicted using data on its position over time (plotted on a hurricane tracking map), thereby allowing meteorologists to make predictions concerning the possible warnings to land areas in the hurricane's path.

Weather maps

- Weather maps can help predict weather patterns by indicating high or low pressure systems (*isobars*), movement of air masses and fronts, or temperature ranges (*isotherms*).
- *Station models* from specific locations provide information that can also be used to predict weather patterns.
- Information found on a station model can include cloud cover, temperature (85°F), wind direction and speed, precipitation (* - snow, ● – rain), or barometric pressure (1002 mb).



Satellites

- Satellite images are used for seeing cloud patterns and movements.
- For example, hurricane clouds and movement can be observed using satellite images.

Radar

- Radar images can be used to detect cloud cover, rainfall or storm location, intensity, and movement, as well as the potential for severe weather (for example, hurricanes or tornadoes).

It is not essential for students to know how to draw weather maps or isobar or isotherm lines. Students do not need to identify other information found on a station model such as the types of clouds, dew point, types of precipitation (other than snow or rain), or change in barometric pressure.

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Assessment Guidelines:

The objective of this indicator is to *predict* weather conditions and patterns based on weather data collected from direct observations and measurements, weather maps, satellites, and radar; therefore, the primary focus of assessment should be to take the presented material from direct observations and measurements, from weather maps, satellite images, and radar and use that information to show what might happen to local or national weather conditions. However, appropriate assessments should also require students to *interpret* a weather map, station model, or hurricane tracking map; *compare* a series of weather maps to show patterns or weather system movement; or *identify* weather symbols commonly found on weather maps.

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6.4.7 Explain how solar energy affects Earth's atmosphere and surface (land and water).

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: This indicator contains new conceptual material. It can be reinforced with concepts in standard 6-5 where solar energy sources and properties are identified (6-5.1), where energy transformation is explained (6-5.2) and where heat energy transfer is illustrated (6-5.5). In high school Earth Science students will further study the effects human activities have had on the atmosphere due to excess greenhouse gases, ozone depletion, and photochemical smog (ES-4.7)

It is essential for students to know that the driving energy source for heating of Earth and circulation in Earth's atmosphere comes from the Sun and is known as *solar energy*. Some of the Sun's energy coming through Earth's atmosphere is reflected or absorbed by gases and/or clouds in the atmosphere.

- The land heats up and releases its heat fairly quickly, but water needs to absorb lots of solar energy to warm up. This property of water allows it to warm more slowly but also to release the heat energy more slowly. It is the water on Earth that helps to regulate the temperature range of Earth's atmosphere.
- Solar energy that is absorbed by Earth's land and water surfaces is changed to heat that moves/radiates back into the atmosphere (troposphere) where the heat cannot be transmitted through the atmosphere so it is trapped, a process known as the *greenhouse effect*.

It is not essential for students to know the electromagnetic spectrum as part of solar (radiant) energy. Students do not have to explain the greenhouse effect in its negative terms based on excess greenhouse gases in the atmosphere.

Assessment Guidelines:

The objective of this indicator is to *explain* how solar energy affects Earth's atmosphere and surface (land and water); therefore, the primary focus of assessment should be to construct a cause-and-effect model of solar energy's impact on Earth's atmosphere and on the land and water surfaces. However, appropriate assessments should also require students to *summarize* the process known as the greenhouse effect; or *identify* factors in the atmosphere that would either reflect or absorb solar energy.

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6-4 The student will demonstrate an understanding of the relationship between Earth's atmospheric properties and processes and its weather and climate. (Earth Science)

6-4.8 Explain how convection affects weather patterns and climate.

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: This indicator contains new conceptual material. It can be reinforced with concepts in standard 6-5.6 where heat energy transfer is illustrated. Students will relate the movement by convection to plate tectonics in 8th grade (8-3.6).

It is essential for students to know that because warm air near Earth's surface rises and then cools as it goes up, a *convection current* is set up in the atmosphere. There are three atmospheric convection areas in the northern hemisphere and three in the southern hemisphere.

- the *tropical region* begins at the equator and extends to the about 30 degrees north latitude;
- the *temperate region* extends from there to about 60 degrees north latitude, and
- the *polar region* extends from there to the north pole, 90 degrees north latitude.

NOTE TO TEACHER: Students will focus their understanding on the northern hemisphere convection regions, or cells:

Convection happens on a global scale in the atmosphere and causes global winds. These winds then move weather systems and surface ocean currents in particular directions.

- Due to the spinning of Earth, the weather systems in these regions move in certain directions because the *global wind belts* are set up (6-4.9).
- On a smaller scale, convection currents near bodies of water can cause local winds known as *land and sea breezes*.
- The *surface currents* of Earth's oceans that circulate warm and cold ocean waters in convection patterns also influence the weather and climates of the landmasses nearby.
- The warm Gulf Stream current water influences the eastern Atlantic shoreline of the United States, while the cold California current influences its western Pacific shoreline.

Because of the unequal heating of Earth, *climate zones* (tropical, temperate, and polar) occur.

- Since temperature is a major factor in climate zones, climate is related
 - to the convection regions at various latitudes,
 - to temperature differences between the equator and the poles, and also
 - to warm and cold surface ocean currents.

It is not essential for students to locate, classify, or identify the characteristics of various global climate regions. This indicator is not a complete study on the conditions related to climate. Climate is only related as an effect of global convection.

Assessment Guidelines:

The objective of this indicator is to *explain* how convection affects weather patterns and climate; therefore, the primary focus of assessment should be to construct a cause-and-effect model of convection's impact on Earth's convection regions, global winds, ocean surface currents, and climate. However, appropriate assessments should also require students to *interpret* diagrams

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related to convection; *compare* convection regions to the global wind belts; or *identify* the convection regions or ocean currents that influence climate along the coasts of the United States.

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6.4.9 Explain the influence of global winds and the jet stream on weather and climatic conditions.

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: This indicator contains new conceptual material. Students will expand on this knowledge in high school Earth Science as they then develop understanding of the Coriolis effect and also look at the causes and evidence for global climate changes. Students will also study geographic influences attributed to global climate patterns.

It is essential for students to know that *global winds* are found in each convection region (6-4.8).

- Because convection cells are in place in the atmosphere and Earth is spinning on its axis, these global winds appear to curve. This is known as the *Coriolis effect*.
- In the global wind belt regions, the prevailing direction of the winds and how air movement in these large regions affects weather conditions.

Global winds

- The *trade winds* blow from east to west in the tropical region moving warm tropical air in that climate zone.
- The prevailing *westerly winds* blow from west to east in the temperate region.
- The temperate zone temperatures are affected most by the changing seasons, but since the westerly wind belt is in that region, the weather systems during any season move from west to east. Since the United States is in the westerly wind belt, the weather systems move across the country from west to east.
- Tropical weather systems, for example hurricanes, are moved in the prevailing direction of the trade winds. If they enter the westerly wind belt, they are often turned, and move in the direction of that prevailing system.
- The *polar winds* blow northeast to west in the polar region moving cold polar air in that climate zone from the poles toward the west.

Jet stream

- A fast-moving ribbon of air that moves from west to east in the Northern Hemisphere around Earth. It dips and bends and constantly changes positions.
- As these changes occur, air masses and weather systems in its path are moved along by the fast moving air.
- The polar jet stream can bring down cold polar conditions from the north.
- The subtropical jet stream can bring warm tropical conditions from the south (in the northern hemisphere).

It is not essential for students to explain the cause of the jet stream or the global wind belts. The effects of latitude, topography, and elevation on climate patterns are not included in this indicator.

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Assessment Guidelines:

The objective of this indicator is to *explain* the influence of global winds and the jet stream on Earth's weather and climatic conditions; therefore, the primary focus of assessment should be to construct a cause-and-effect model of how weather and climatic conditions are moved by global winds and also how the jet stream moves weather systems in the Northern Hemisphere.

However, appropriate assessments should also require students to *interpret* diagrams related to global winds or the jet stream; *compare* the movement of weather systems between the global wind belts; *identify* the wind belts and their prevailing wind directions; or *recall* the curving of global winds as the Coriolis effect.